Advanced Surfaces And Processes, Inc.

ElectroSpark Deposition
studies for gas turbine engine component repair

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HCAT Program Review Meeting
Grandover Resort & Conference Center
Greensboro, NC 27407

Report Documentation Page

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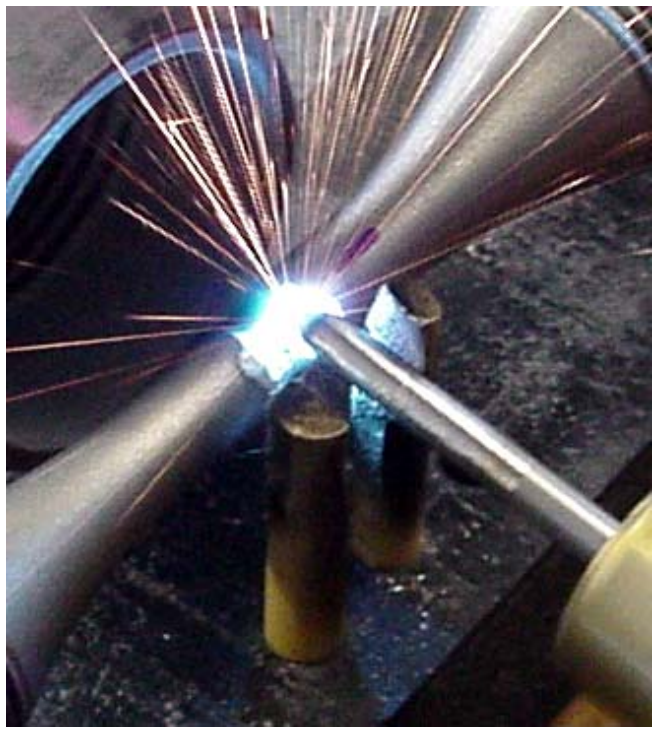
Project Objective

The goals of this project are to *demonstrate and validate* ElectroSpark Deposition (ESD) as technically feasible and commercially viable for a production-scale process, and to perform the tests necessary to transition ESD for use on gas turbine engine components.



Participants

- ESTCP/HCAT
- PEWG
- Portland State University
- Edison Welding Institute
- Rowan Technology Group
- Pacific Northwest National Lab
- Air Force Research Lab
- General Electric Aircraft Engines
- Pratt & Whitney
- Tinker AFB

What is ESD?

The ESD process is comprised of an electric arc through a consumable electrode energized by a series of capacitors. During the generation of the arc, small particles of the electrode material are melted and build-up occurs incrementally.

- Metallurgical bond
- Low heat input
- Rapid solidification
- No pre-ESD preparation
- No post-ESD processing
- Environmentally benign
- Portable
- Applicable for NLOS

Demonstration Plan

- *Execution of a Joint Test Protocol*
- *Joint Test Report due 2006*
- *Component Specific*
- *Cost/Benefit Analysis performed by CTC*
- *Materials of Interest*
  - *IN718 on IN 718*
  - *410 SS on 410 SS*
  - *Ti-6Al-4V on Ti-6Al-4V*
  - *IN 718 on chrome plated IN 718*

EPP0202 Demo Plan Revision A.doc

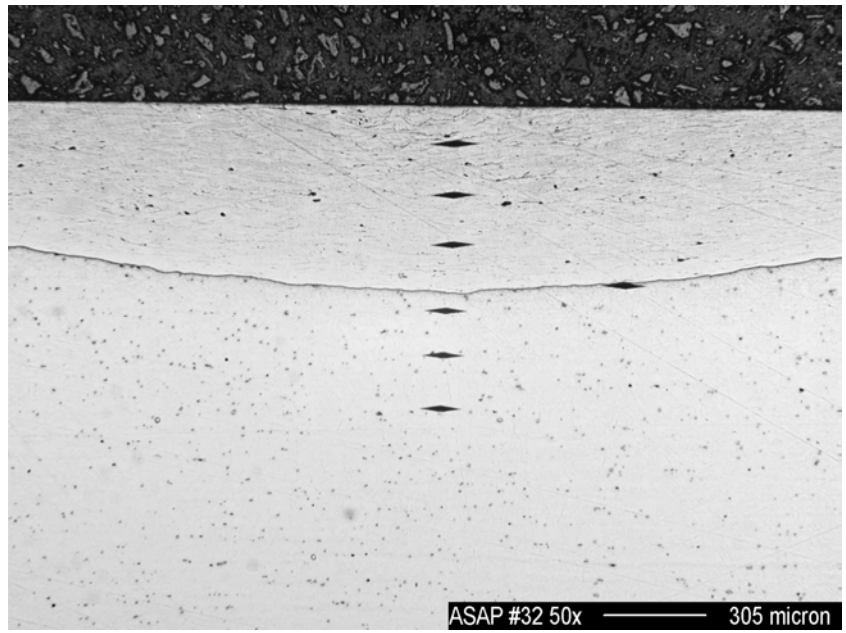
www.hcat.org

HCAT Member WorkSpace →ESD→Test Plans→Demonstration Plan

http://207.152.96.131/w2g/cgi/kmcgi.exe?O=DIR0000000GPM&V=0

Optimization

- *IN 718 on IN 718*
- *DOE Optimization*
- *Added UIT*
- *Metallurgical Evaluation*
  - *Deposition Rate*
  - *Microhardness*
  - *Porosity*
- *Two Parameter Sets Selected*



Optimization Document Project # EPP 0202 (January 2005)
www.hcat.org
http://207.152.96.131/w2g/cgi/kmcgi.exe?O=DIR0000000GPM&V=0

Joint Test Protocol

- *Pin on Disk Wear*
- *Fatigue*
- *Residual Stress*
- *Corrosion*
- *Adhesion Bond*
- *Tensile*
- *Hamilton Sundstrand Wear*

JTP Project # EPP 0202 (January 2005)

www.hcat.org

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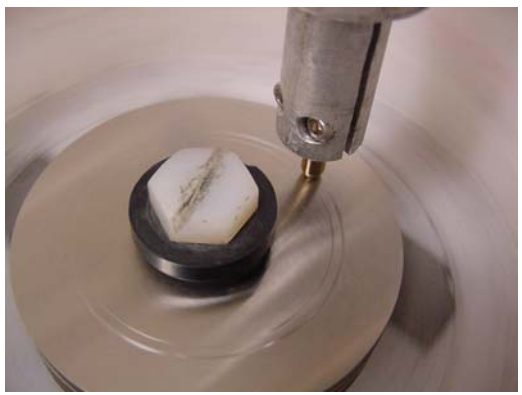
Pin on Disk Wear

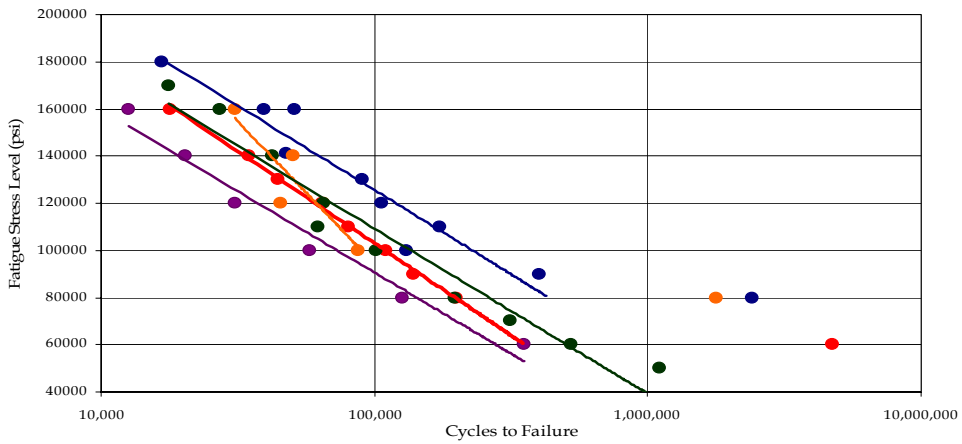


Specimen	Maximum Groove Depth	
	Base Metal	ESD
2-1	114	134
2-2	92	153
2-4	128	123
2-3 (long test)	218	194

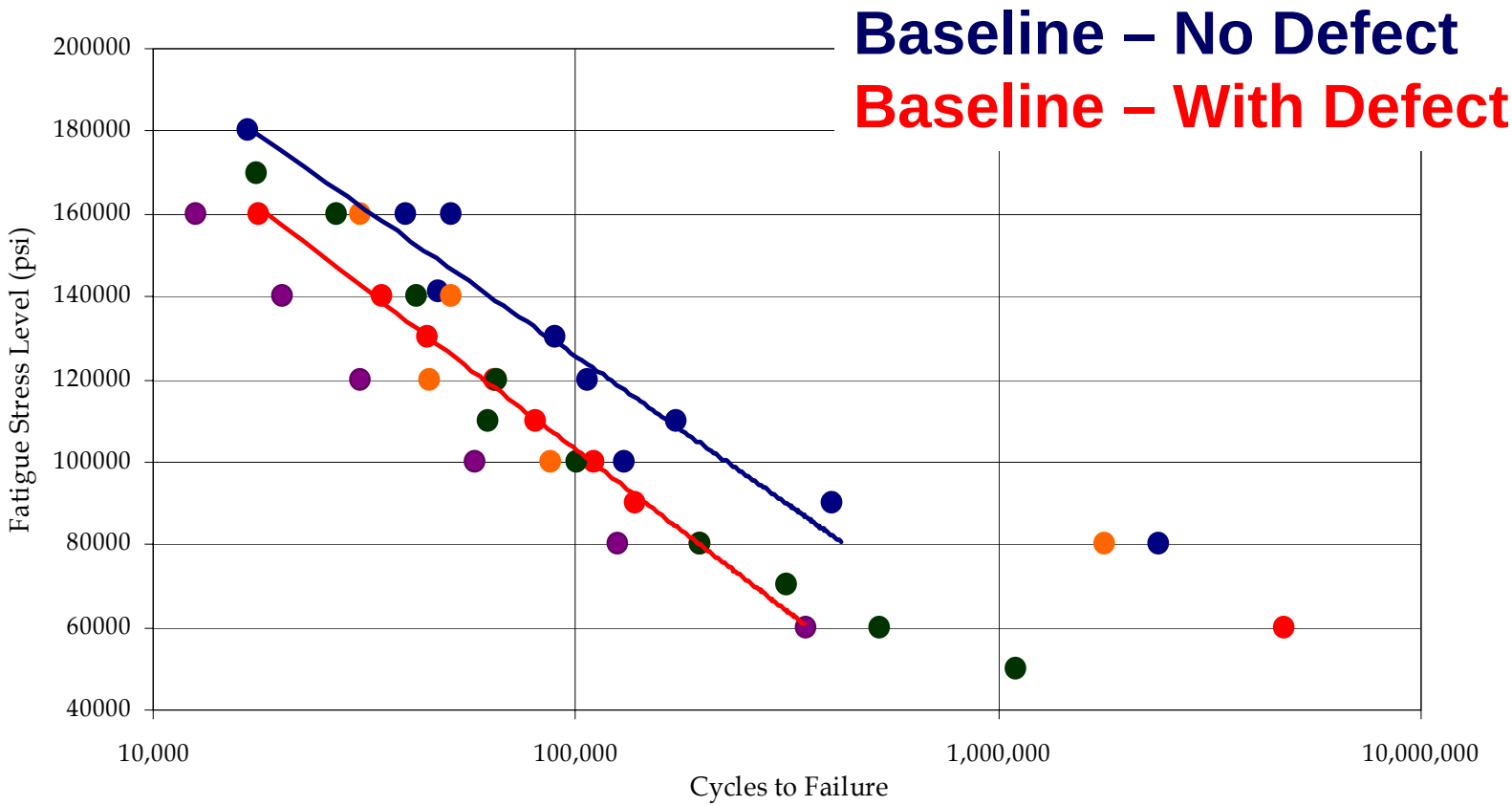
Fatigue


INSTRON
14.12.2004

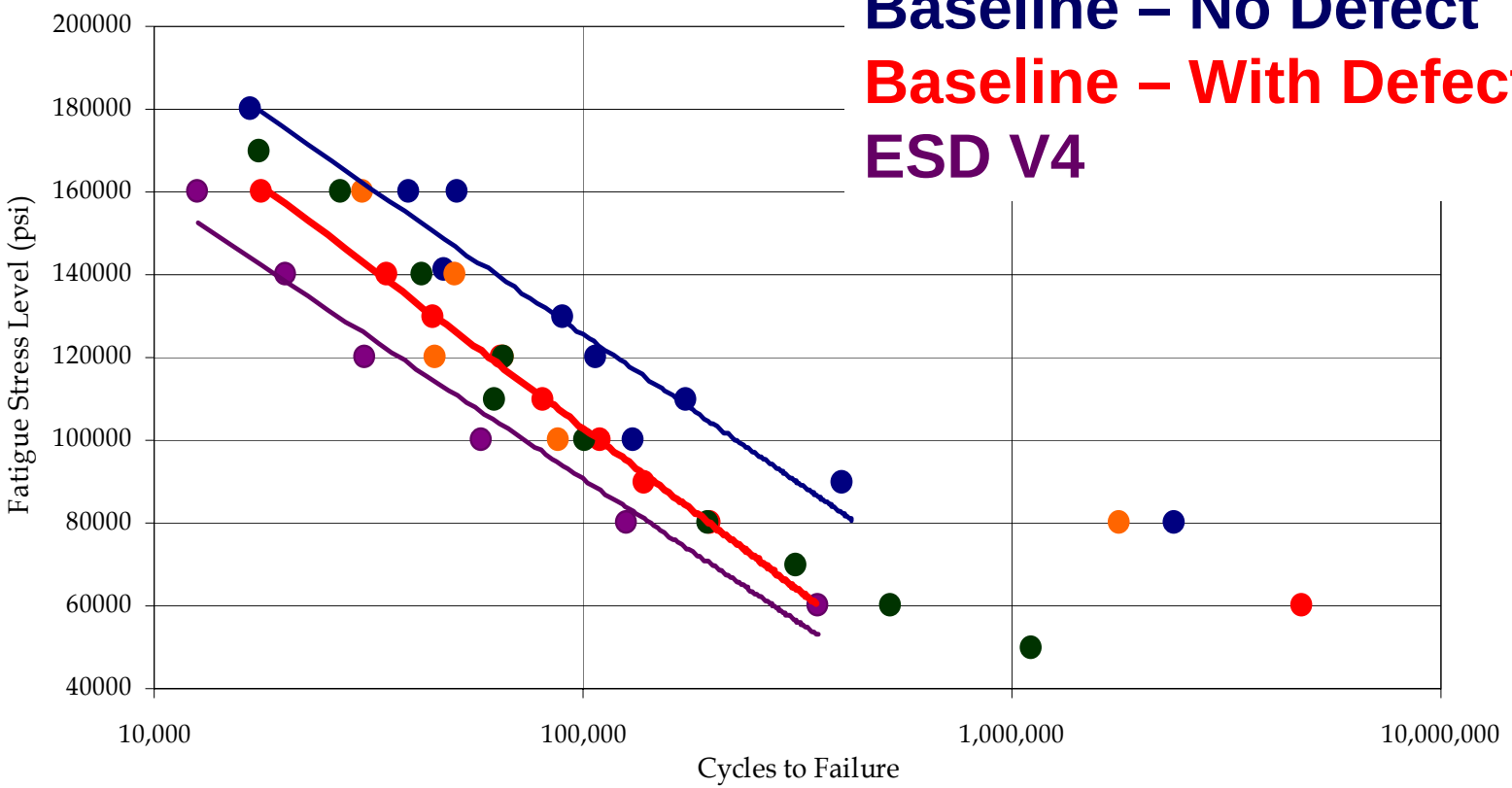

FAT-13


200000
180000
160000
140000
120000
100000
80000
60000
40000
Fatigue Stress Level (psi)
10,000
100,000
1,000,000
10,000,000
Cycles to Failure

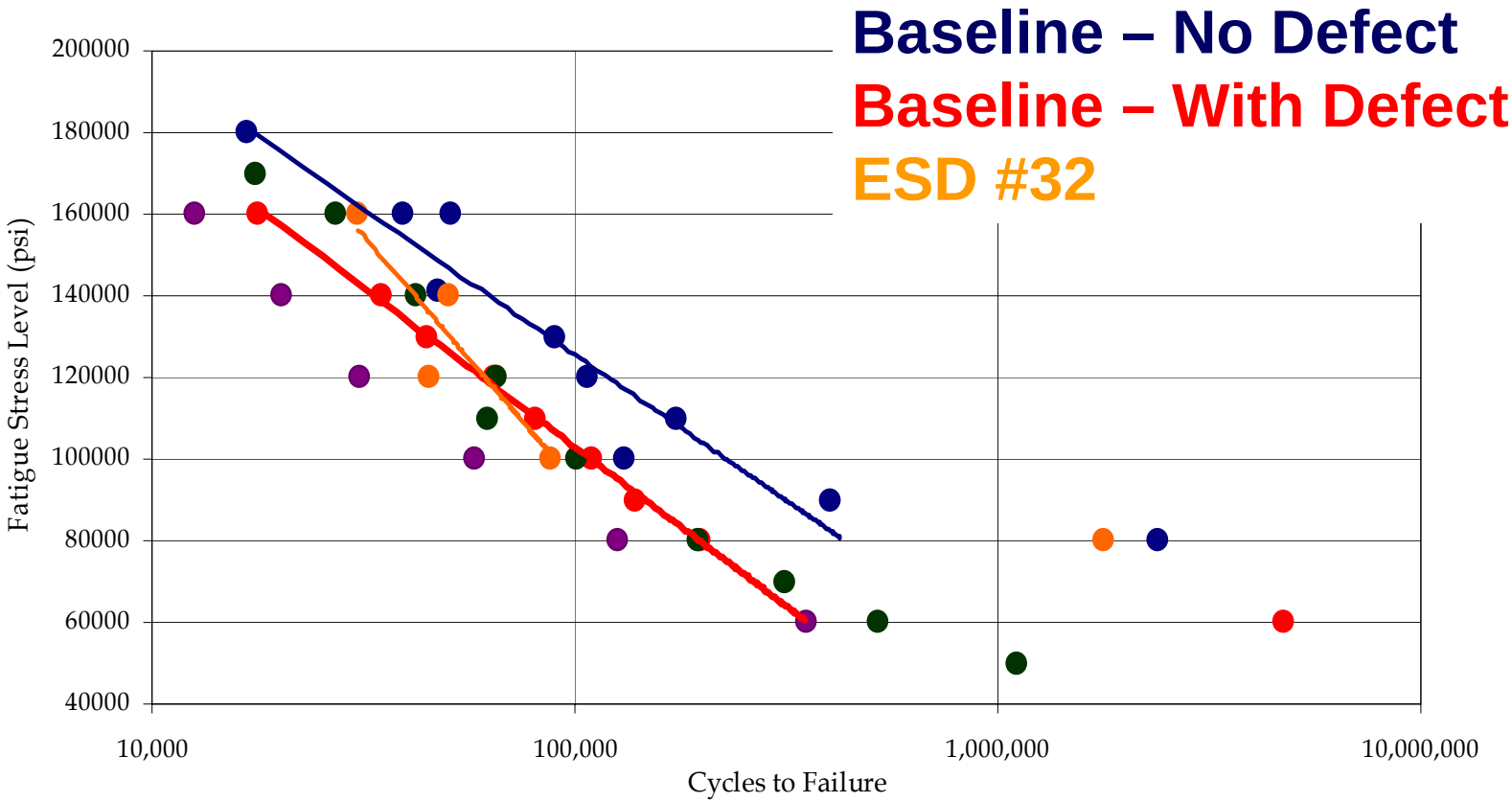
Fatigue


Baseline – No Defect
Baseline – With Defect
200000
180000
160000
140000
120000
100000
80000
60000
40000
Fatigue Stress Level (psi)
10,000
100,000
1,000,000
10,000,000
Cycles to Failure

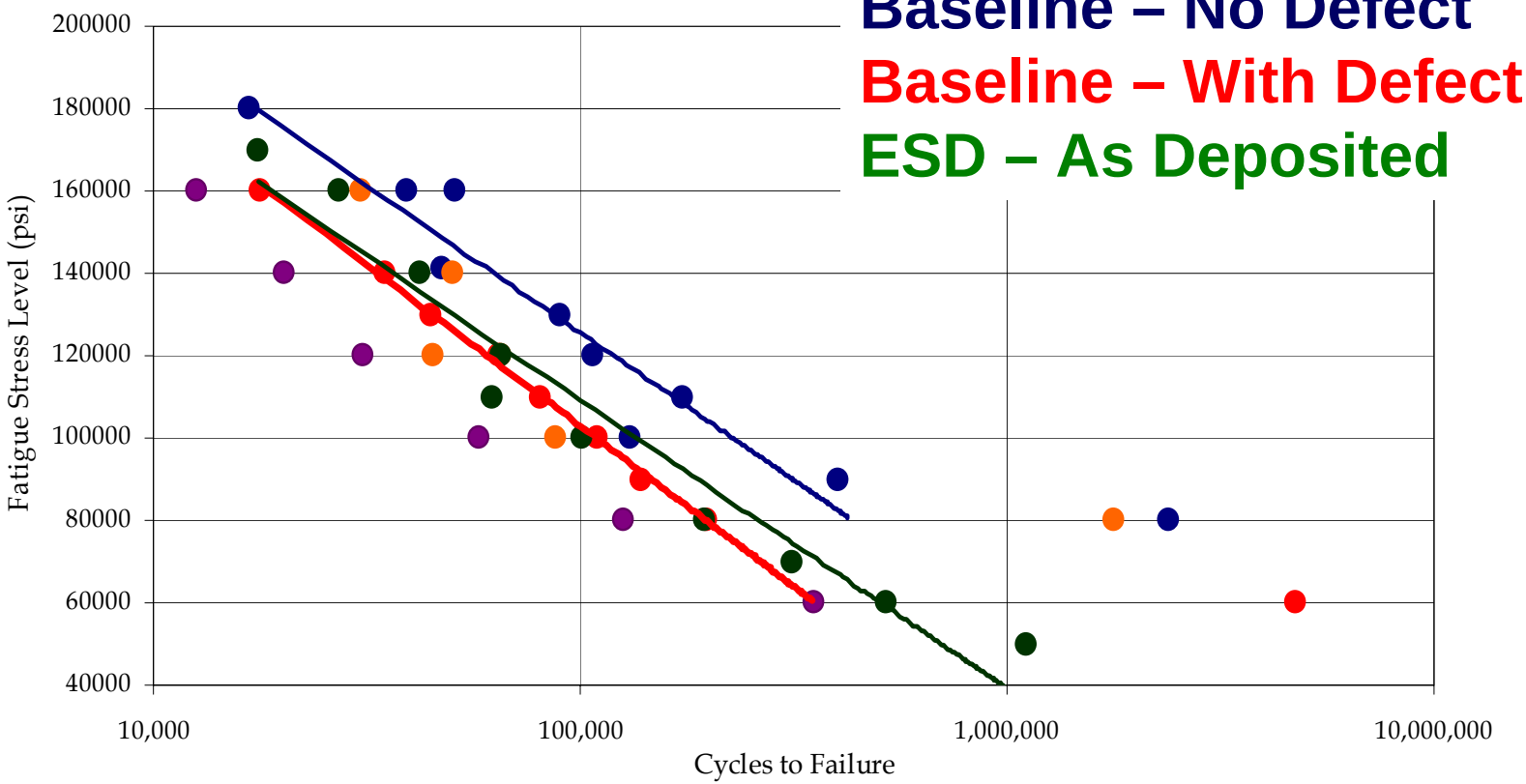
Fatigue


Baseline – No Defect
Baseline – With Defect
ESD V4
200000
180000
160000
140000
120000
100000
80000
60000
40000
Fatigue Stress Level (psi)
10,000
100,000
1,000,000
10,000,000
Cycles to Failure

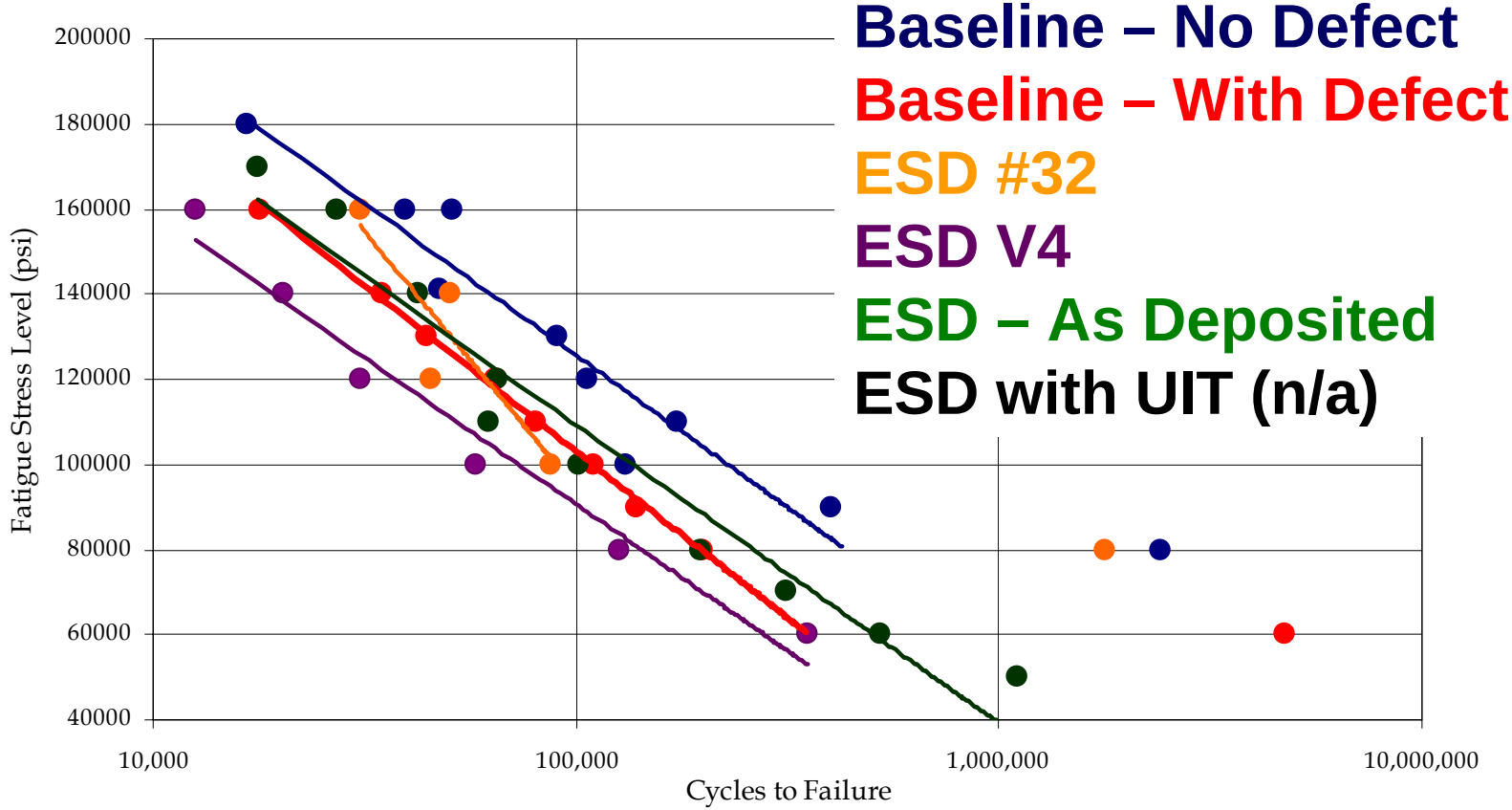
Fatigue


Baseline – No Defect
Baseline – With Defect
ESD #32
200000
180000
160000
140000
120000
100000
80000
60000
40000
Fatigue Stress Level (psi)
10,000
100,000
1,000,000
10,000,000
Cycles to Failure

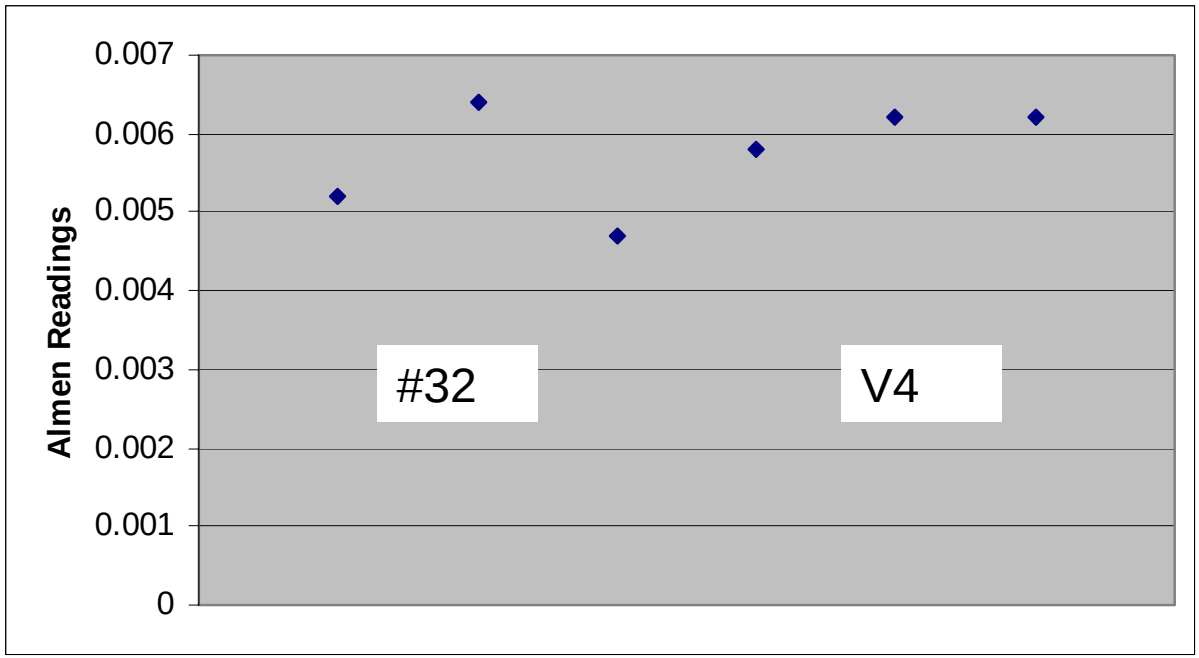
Fatigue


Baseline – No Defect
Baseline – With Defect
ESD – As Deposited
200000
180000
160000
140000
120000
100000
80000
60000
40000
Fatigue Stress Level (psi)
10,000
100,000
1,000,000
10,000,000
Cycles to Failure

Fatigue


Baseline – No Defect
Baseline – With Defect
ESD #32
ESD V4
ESD – As Deposited
ESD with UIT (n/a)
Fatigue Stress Level (psi)
200000
180000
160000
140000
120000
100000
80000
60000
40000
10,000
100,000
1,000,000
10,000,000
Cycles to Failure

Residual Stress



- *Tensile stresses with ESD*
- *Higher tensile stresses with increased energy*
- *Investigating stresses in ESD with UIT*

Corrosion

- *Preliminary corrosion testing conducted following ASTM G-48, heated ferric chloride.*
- *Salt Fog ASTM B117 to be performed*

Adhesion Bond

- *ASTM C 633 to be performed*

Tensile

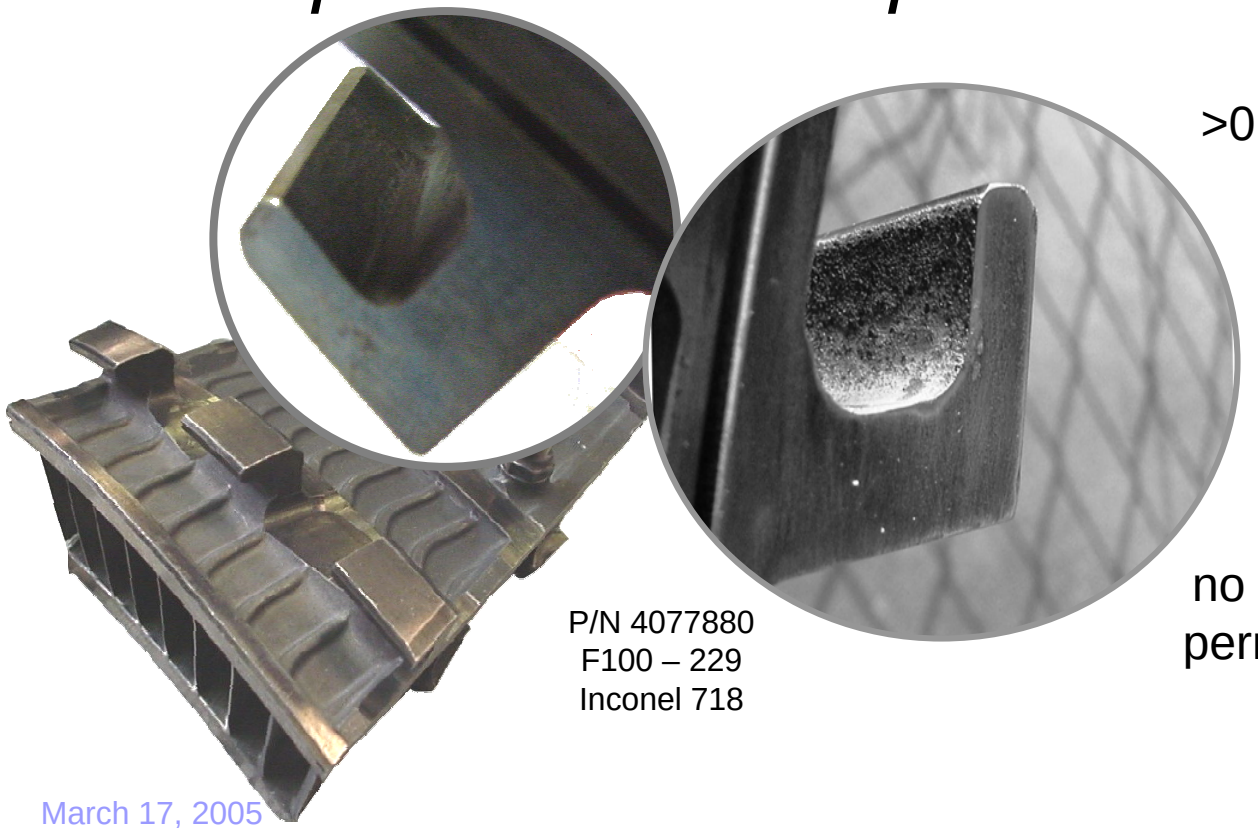
- *Tensile specimens being prepared by ASAP*
- *Some specimens will receive UIT*
- *Specimens sent for final surface finishing*
- *Tensile testing to be performed by PSU*

Hamilton Sundstrand Wear

- *Specimens to be procured and prepared by ASAP*
- *Some specimens will receive UIT*
- *Specimens sent for final surface finishing*
- *Wear testing to be performed by Hamilton Sundstrand*

10-12 Stator Segment

- *ESD parameters under evaluation via JTP*
- *ESD process technique developed*



P/N 4077880
F100 – 229
Inconel 718

>0.005” deep wear in hook
non-line-of-sight

Current repair:
Cut off hook,
weld on new,
heat treat part

no repair if the part has met permissible heat treat cycles

JTP for other materials

- *410 SS on 410 SS*
- *Ti-6Al-4V on Ti-6Al-4V*
- *IN 718 on chrome plated IN 718*

Other ESTCP/HCAT/PEWG Activities

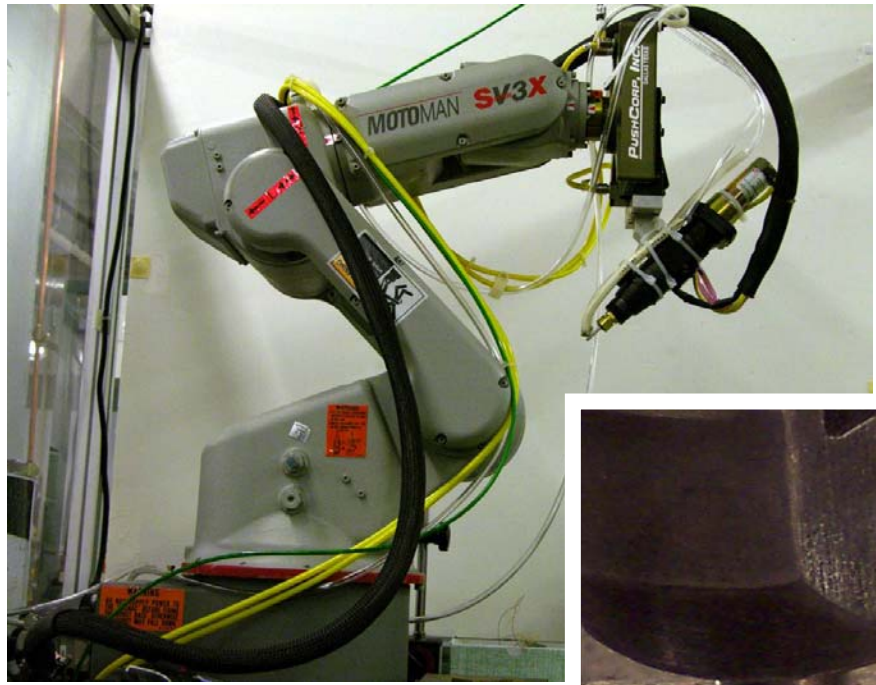
- *Chrome Plate repair*
- *Particle Emission testing*
- *ESD/Robotics/UIT*
- *#5 Bearing Housing*

ESD, Robotics and UIT

Improvement in ESD

Automated with UIT vs. Manual

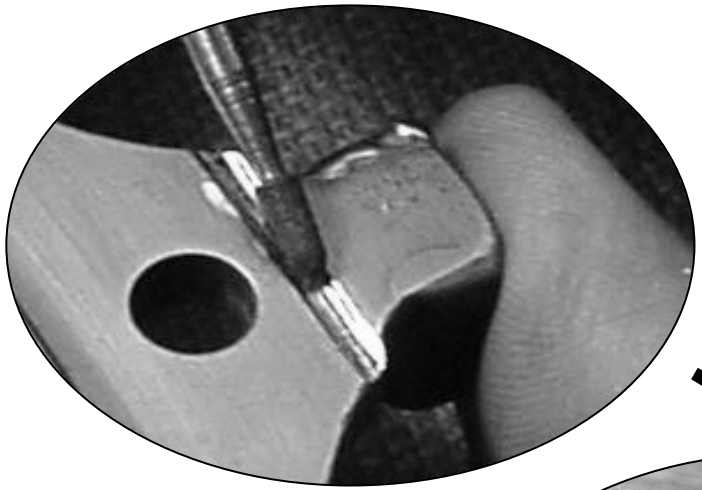
Production Deposition Rates	↑	11 X
Discontinuities	↓	0.8 X
Hardness	↑	1.3 X



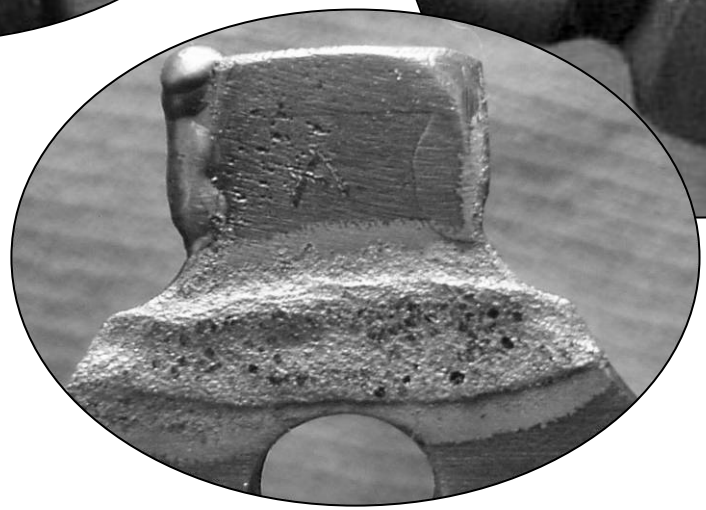
#5 Bearing Housing

P/N 712141
TF 33
AMS 5613
(410 stainless steel)

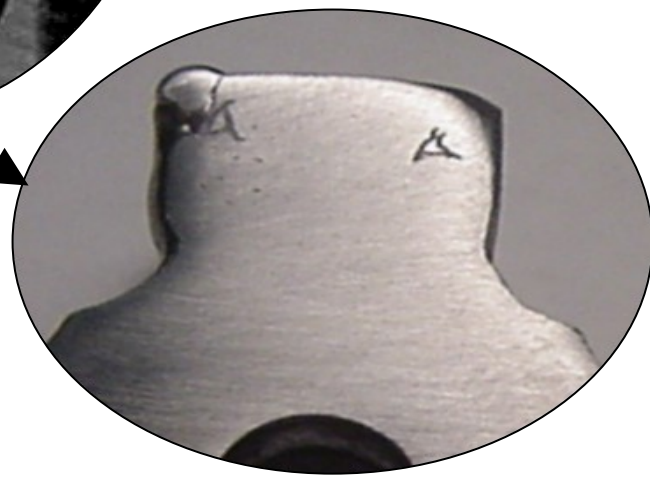
#5 Bearing Housing



Excavate
the defective area

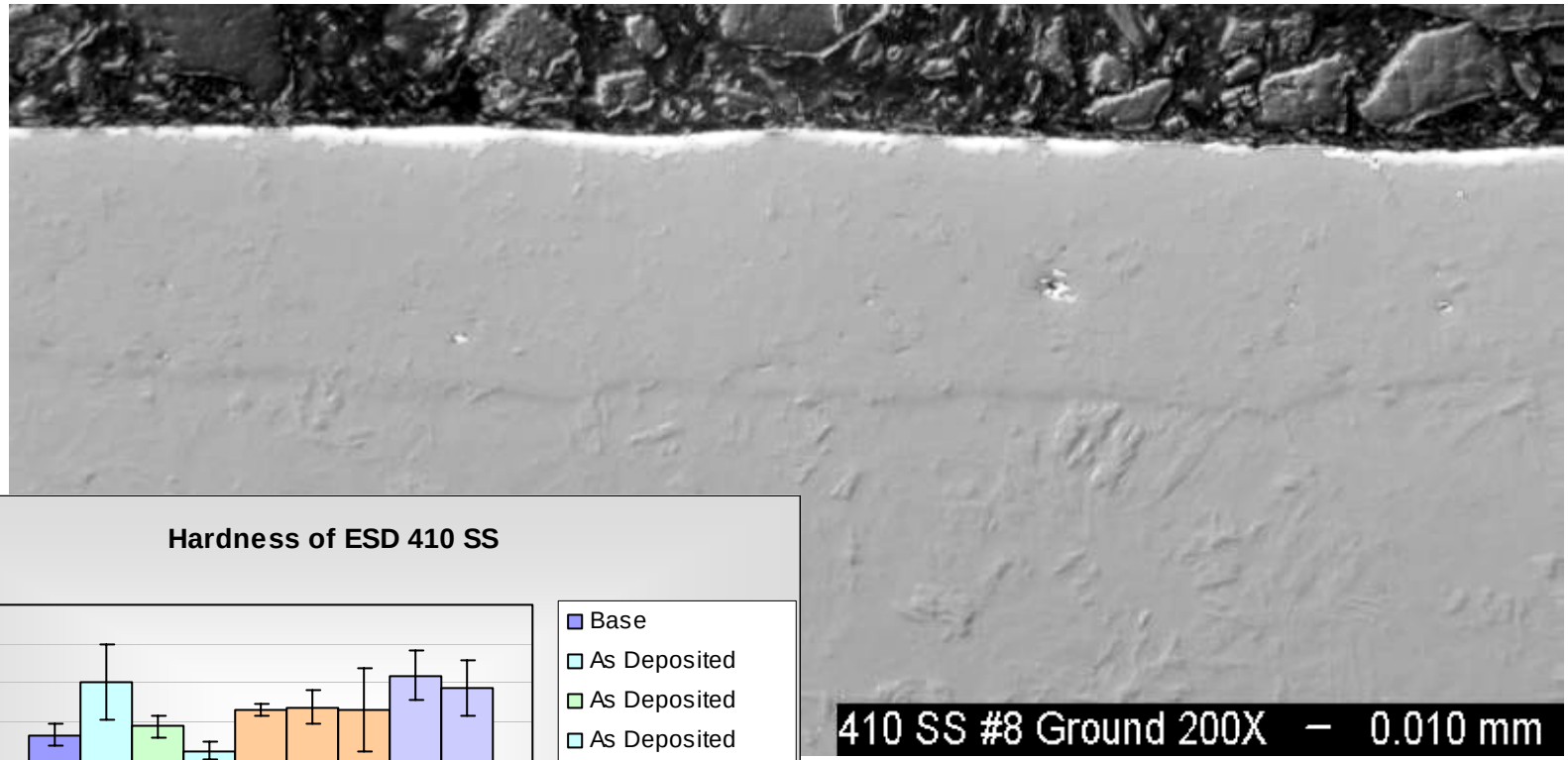


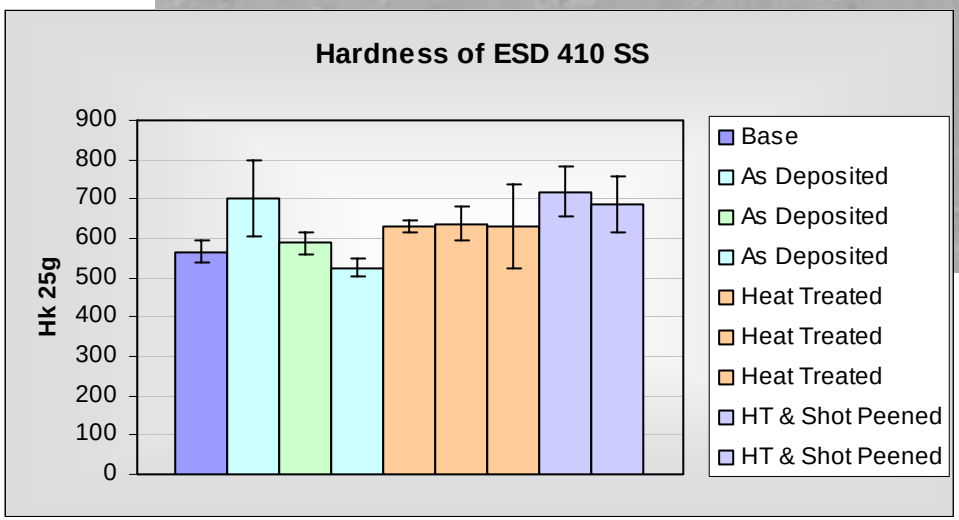
Fill with ESD



Blend to original surface

#5 Bearing Housing





Welding Procedure Specification and hands on demonstration delivered at PEWG, Las Vegas, April 2004.

ElectroSpark Deposition

studies for gas turbine engine component repair

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